

Final Report

“High Resolution Doppler Imager FY 2001, 2002, 2003 Operations and Algorithm Maintenance”

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Wilbert Skinner, P.I.

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Introduction

This report summarizes the activities of NASA grant NAG5-10812 “High Resolution Doppler Imager FY 2001, 2002, 2003 Operations and Algorithm Maintenance.”

Operations Summary

During the performance period of this grant HRDI operations remained nominal. The instrument has suffered no loss of scientific capability and operates whenever sufficient power is available. Generally, there are approximately 5-7 days per month when the power level is too low to permit observations. Figure 1 show the daily latitude coverage for HRDI measurements in the mesosphere, lower thermosphere (MLT) region. This figure shows that during the time of this grant, HRDI operations collected data at a rate comparable to that achieved during the UARS prime mission (1991 - ~1995). Data collection emphasized MLT wind to support the validation efforts of the TIDI instrument on TIMED, therefore fulfilling one of the primary objectives of this phase of the UARS mission. Skinner et al., (2003) present a summary of the instrument performance during this period.

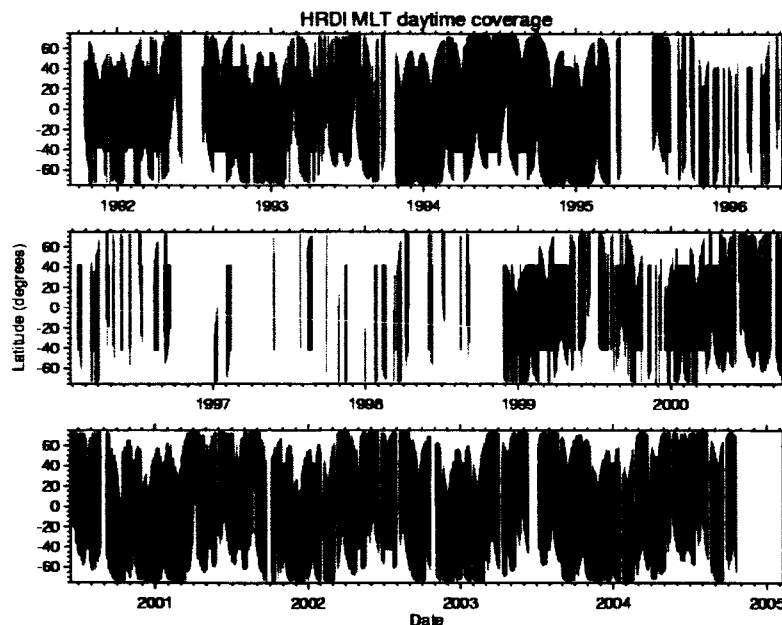


Figure 1. Latitude coverage for HRDI daytime mesosphere and lower thermosphere measurements from launch until mid-2004. A vertical line is drawn covering the latitude extent for each day the instrument performed measurements in this altitude region.

Issues

The only operational issue that impacted the HRDI instrument is the uncertainty in the attitude knowledge of the UARS spacecraft. Since the failure of the second star sensor the UARS attitude has been determined by using the three-axis magnetometer (TAM) and the sun sensor. This has resulted in a degradation of quality of the attitude information. The HRDI data provide a means estimate the roll and pitch of the UARS spacecraft. HRDI observes emissions from rotational lines of the O₂ Atmospheric band and during the day this emission peaks at about 85 km with only a small dependence on solar zenith angle. If HRDI observations combined with the reported attitude indicate the layer peaks at various altitudes during the day, this indicates an attitude uncertainty. Figure 2 shows brightness profiles collected on 24 August 2002 from each of the 4 nominal look directions (45, 135, 225, and 315 degrees with respect to the velocity vector). There is a clear variation in the peak heights, which should lie along the blue crosses.

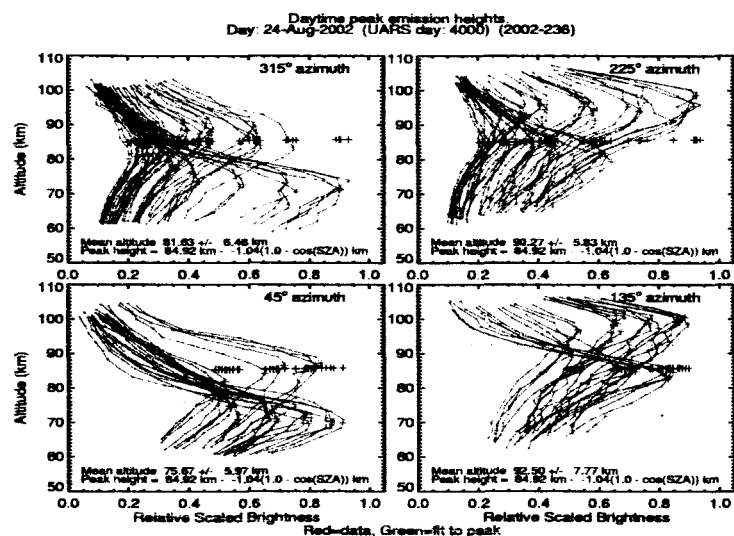


Figure 2 Brightness profile of the 13076.318 cm⁻¹ O₂ Atmospheric band rotational line on 24 August 2002 after the failure of the second star tracker. The profiles are sorted with increasing solar zenith angle with each succeeding scan slightly offset to the right for clarity. If the attitude knowledge were perfect the peaks of the layers would align with the blue plus signs.

While figure 2 looks rather random, the attitude variations are quite systematic. Figure 3 shows the peak altitudes plotted against the spacecraft track angle for the same day as shown in figure 2. This shows the attitude varies systematically along the orbit and repeats from orbit to orbit. A simple model has been developed to calculate the roll and pitch offsets as a function of track angle for any given day (no information about yaw can be determined by this method.). The model assumes a once per orbit oscillation about a mean offset. Also shown in figure 3 are the results of the model fitting and it can be seen that the fits are quite good. The behavior of the attitude varies from day to day as shown in figure 4. In that figure the mean pitch offset is shown for a 300-day period. The pitch offset varies with the solar beta angle, being small at small beta angles and attaining a maximum at the highest beta angles. This issue is currently being addressed and it is

expected that good attitude can be recovered for this time period allowing for data processing and distribution.

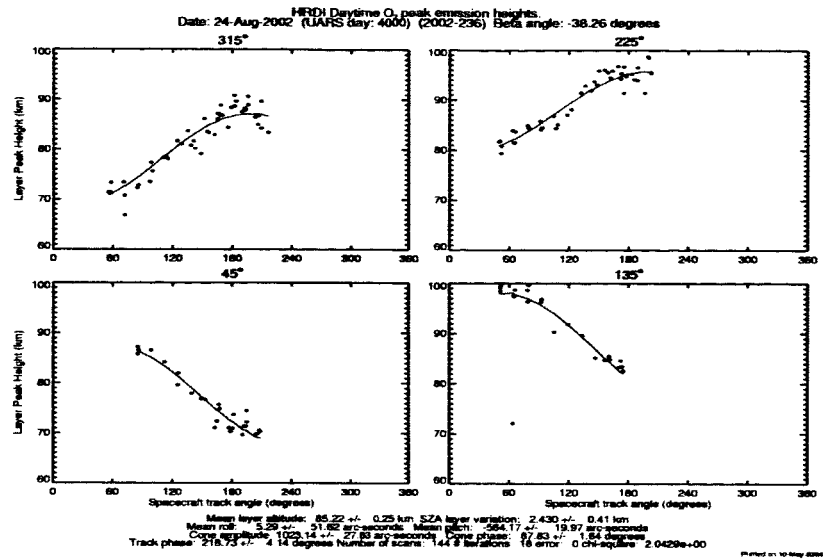


Figure 3. Peak altitudes as a function of spacecraft track angle (dots) and the least squares fit (line).

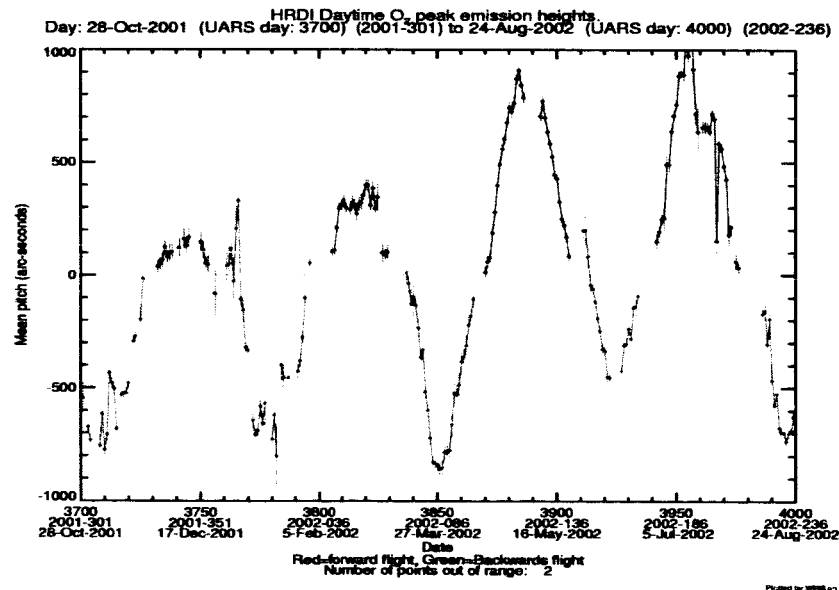


Figure 4. Fit to the mean roll shown for a 300 day period after the failure of the star tracker. Parameters are assumed constant for a day, but allowed to vary each day. Each day's fitting is independent. The mean pitch shows a strong dependence on flight direction and solar beta angle.

REFERENCES

1. W. R. Skinner, A. R. Marshall, D. A. Gell, J. Raines , "The High Resolution Doppler Imager: Status update 12 years after launch," in *SPIE Conference on Optical Spectroscopic Techniques and Instrumentation for Atmospheric and Space Research V*, edited by Allen M. Larar, Joseph A. Shaw, and Zhaobo Sun, San Diego, Ca., SPIE **5157**, 231-241, 2003.